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# Japan Report

## SCIENCE AND TECHNOLOGY



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## SCIENCE AND TECHNOLOGY

## CONTENTS

TRANSPORTATION



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# VARIOUS FORMS OF SPACE UTILIZATION EXAMINED

## Observation Systems, Space Environment

Tokyo TSUSANSHO JANARU in Japanese Apr 86 pp 20-22

[Article by Hajime Furuta, chief of the Space Industry Office, Machinery Information Industrial Bureau: "Toward New Frontiers in Space"]

{Text] Man launched a satellite into space for the first time in 1957, the Soviet Sputnik 1. Since then, the United States and the Soviet Union have desperately competed with each other in space development, so that the number of satellites launched throughout the world now exceeds 2,000. It is becoming an age also when manned activities in space with the use of space shuttles are a daily topic of conservation.

Japan's space development began with the successful launching in 1955 of a pencil rocket just 23 cm long. In 1970 Japan's first artificial satellite Osumi was launched, and Japan became the fourth country after the United States, the Soviet Union, and France to succeed in launching a satellite by its own efforts. Since then the number of satellites launched up to now has reached 15 scientific satellites, which included the Suisei launched in August 1985 to observe Halley's comet, and 17 practical satellites, such as communications, broadcasting, and weather, including the broadcasting satellite Yuri IIb launched in February this year. Lately, the utilization of satellites for weather forecasts, and for communications such as telegraph and telephone, television broadcasting, etc., has become indispensable and deeply concerns our life.

The Ministry of International Trade and Industry (MITI) from the standpoint of being in charge of the natural resources and energy policy, is promoting the earth resources satellite No 1 (ERS-1) program aimed mainly at resources probing and at the same time, conducting the development of an unmanned space experiment system (free flier) for experiments using the microgravity of space, thereby promoting the industrial utilization of the space environment which is expected to result in a considerable breakthrough in the development of industrial technologies.

Development of ERS-1

The field of earth observation has been drawing attention as a new field in satellite utilization in recent years. A satellite orbiting at an altitude of several hundreds of kilometers above the earth observes the condition of oceans and land using sensors, etc., and sends data to earth via radiowave.

The United States has already launched eight earth resources satellites with the Landsat 1 as the start in 1972.

MITI, from the standpoint of establishing security in stable supply of natural resources and energy and developing an effective resources policy, began development of the Earth Resources Satellite 1 (ERS-1) aimed mainly at probing mineral resources such as petroleum jointly with the Science and Technology Agency in fiscal 1984, with the goal set for launching in fiscal 1990. The ERS-1 is the world's first land observation satellite aimed mainly at resources probing, and the total development expenditure reached about ¥70 billion, including developmental expenses etc. for the launcher, the H-I rocket.

MITI is partially responsible for the research and development of such observation systems as the synthetic-aperture radar and the optical sensor to be mounted on the ERS-1, and is conducting it under the system of the large-scale research and development program of the Agency of Industrial Science and Technology.

The synthetic-aperture radar is a system to observe very minute ruggedness, etc., of the earth's surface by catching the reflection of microwaves emitted from the satellite, and differs from the optical sensor that passively catches reflected sunlight. It can obtain data on the earth's surface regardless of cloud cover or whether it is day or night. Further, it is believed to be capable of observing the earth's surface even through a number of trees. Thus, with regard to utilization of that data, great expectations are entertained by users in wide-ranging fields, and, of course, resource users.

The optical sensor to be mounted on the ERS-1 is characterized as having a short-wavelength infrared region containing an effective wavelength region for probing petroleum resources and has an extremely good resolution of about 18 m (30 m in the Landsat 5).

As such, although the ERS-1 is expected to provide a great deal of useful information for resources probing, with regard to the utilization of satellite data, the research and development of a special massive image-processing technology using a high-speed computer, analytical technology for extracting characteristics showing the possible presence of resources from the satellite picture, etc., is essential. MITI is conducting research and development on this satellite-data-utilization technology in parallel with research and development of the ERS-1.

## Toward New Space Utilization Age

The total sales of Japan's space industry stood at about ¥170.3 billion in fiscal 1983, of which sales for governmental agencies such as the National Space Development Agency accounted for about 60 percent. For the past 2 or 3 years such sales, reflecting the possible national financial condition, indicate stagnant growth.

During the past few years, on the other hand, the field of utilizing the environment, such as the microgravity of space, has become closely viewed as new space utilization. This type of utilization is called the "space environment" utilization as against "position" utilization in terms of the altitude of space in such instances as communications and broadcasting satellites up to this time.

As for material experiments, etc., using the microgravity of space, the Skylab program of 1973 and others has already been underway for some time and this field has quickly drawn attention in recent years. This is because as the space shuttle is put to practical use and the space station program goes into full swing, the utilization of the space environment has increased prospects in the industrial field not merely as an intellectual interest of scientists, but also as having great impact on technical reform in extremely far-reaching fields.

For instance, under space microgravity, precipitation, heat convection, etc. do not occur due to the specific gravity difference of materials, and there is the possibility to manufacture high-purity, less defective, uniformly composed large-scale semiconductor crystals which are difficult to manufacture on earth due to the influence of gravity. Also, it may be possible to obtain perfectly shaped large-type protein crystals that could be destroyed onto earth due to the influence of gravity.

It is expected that such space environment utilization experiments will bring about much new knowledge that not have been acquired by ground experiments. With achievements contributing greatly to the progress in the development of high technologies in such industrial fields as electronics, biotechnology, and new materials, in the future, even a business using the space environment may not be a dream.

## For Full-Scale Space Environment Utilization

The United States and Europe, "space environment utilization" has already been strongly promoted.

In the United States, as the space shuttle is put to practical use, various means of space environment utilization experimentation using the cargo compartment have been planned and put to use not only by national organs such as NASA, but also to a wide range of private firms. NASA is strongly promoting measures in support of the private sector aimed at promoting commercialization of space, and under its backup many private firms from major enterprises to small venture business firms are grappling with space environment utilization.

In Europe, particularly West Germany is enthusiastic about space environment utilization. It is promoting the D program to conduct materials experiment, etc. in a space lab developed to use the cargo compartment of the space shuttle as a space experimentation room. Moreover, the European Space Agency (ESA) jointed by 11 European countries is also conducting experiments by space lab and promoting the development of EUREKA, the unmanned free flier for such purposes as astronomical observation, materials experiment, and other projects.

In Japan, too, where the space station program is in full scale, interest by industrial circles in space environment utilization is rapidly increasing; however, Japan has obtained hardly any positive results at all in space experiments using microgravity. In order also not to fall behind Europe and the United States, which are already ahead, it is considered necessary for Japan to come to grips with this field quickly on a full scale.

At present, however, as Japan does not have an independent means of space experimentation, it is difficult for it to secure periodic and repetitive experimental opportunities indispensable to materials experimentation, etc.

Thus MITI plans to start research and development on an unmanned space experiment system (free flier) to conduct experiments instrument to the development of industrial technologies by using the microgravity environment of space in fiscal 1986, with the target for its launching set at about fiscal 1992.

The unmanned space experiment system is put in space by the space shuttle and conducts unmanned experiments of materials, etc. automatically for several months. The experimental data are transmitted via radiowave to the space shuttle of the receiving station on earth and analyzed. Further, the samples after the experiment are recovered by space shuttle individually or together with the system and are brought back to earth and analyzed.

In comparison with the manned space experiment methods such as the space lab, as it is possible by the unmanned space experiment system to acquire high-quality microgravity of one several thousandths to one several ten thousandths and to conduct long-term experiments over several months, it is suitable for full-scale industrial technology developmental experiments such as semiconductor crystal growth.

With a start in operation of this unmanned space experiment system, space environment utilization by the Japanese industries is anticipated to become highly advanced and reach a higher extent. Until then, however, it is important to utilize as fully as possible the experimental opportunities of the manned space experiment methods from abroad, such as the space lab, and to strive to accumulate technical knowledge.

Also, after the mid-1990s when the manned space station now under preliminary design with the cooperation of the United States, Europe, Japan, and Canada and U.S. President Reagan support begins operating, it is expected that by comprehensive utilization with the unmanned space experiment system, space environment utilization will make rapid progress.

The explosion of the space shuttle at the end of January of this year was a great shock to the entire world, particularly those involved in space development. However, all countries, including the United States itself, have also expressed firm resolve to positively tackle the frontier known as space in the future, overcoming this great sorrow.

Japan, too, is expected to carefully and boldly challenge space, which is expanding its frontiers from communications and broadcasting to earth observation and space environment utilization as a seedbed of high-tech industrial technologies development.

## Underground Resources

Tokyo TSUSANSHO JANARU in Japanese Apr 86 pp 24-25

[Article by Yasuaki Ishiwada, consultant, Resources Observation Analysis Center (Incorporated Foundation): "Underground Resources When Seen From Space--Prospecting and Satellite Remote Sensing"]

[Text] Identification of terrestrial rocks and strata from space has become possible by remote sensing (probing distances). For Japan, which relies greatly on resources, from abroad its utilization is an important issue not only from the standpoint of possible supply, but also international relations.

### Color Image From Landsat

When visiting Washington last fall, the author saw a beautiful color photo taken by Landsat 5.

It was in a conference room of a firm known well for its picture processing and interpretation of satellite data, and the photograph was a map of Muscat and Oman on a scale of 1/100,000 the size of an entire newspaper page. This is the area where one can actually see the world-famous extensive ophiolite rise onto the continent; that is, the seabottom in the Cretaceous lithosphere, which is, so to speak, a fossil oceanic crust. Although this was more than a little interesting, what was impressive was that the rocks and strata could be precisely identified on this "photograph." This was the result of computer processing using three bands of the visible light and short wavelength infrared region from the memory of the multiband optical sensor called the thematic mapper, but it is as well-made as a true geological map.

Based on black-and-white aerial photography that came to Japan soon after the war, photogeology quickly becoming popular in Japan also and is the basis of today's resources remote sensing. However, since the aerial camera was replaced by the multichannel wavelength-band scanning system sensor of the satellite, computer processing has become easier, and with the combination of information engineering and computer technology progress, it has produced splendid results that go beyond the confines of mere photography.

## Role and Advantages of Remote Sensing

What is the role of remote sensing in prospecting for underground resources? The technical philosophy and methodology of prospecting vary with the type of resource, such as petroleum, metal, and terrestrial heat. In a word, however, the system of prospecting consists of a series of work in collecting and analyzing geological information on the theory of the origin of each mineral deposit as the basis, grasping direct and indirect indications of potential mineral deposits, and finally confirming their existence and the properties of the mineral deposit by boring and other means.

To cite a case in petroleum prospecting, the prospecting begins with the assembly of existing literature and unpublished data on such matters as geology, geological structure, history of crust alteration, paleogeographic changes geo-chemistry, and the geothermal gradient of a wide sedimentary basin. After determining the possibility of oil field formation by geological appraisal of this extensive area, various sensing technologies are put together to increase the accuracy of appraisal in one's own concession area and trial boring is conducted by selecting the most likely site. Since trial boring can directly investigate the underground strata, it is also a very important source of information for advancing to the next step whether there is petroleum seepage or not.

Remote sensing is superior in its contribution to the initial stage of such prospecting process.

Remote sensing originally was the means of investigating phenomena near the earth's surface through reflection and radiation of electromagnetic waves, and when combined with other information and data, particularly relating to underground geology, it demonstrates a synergistic effect. In other words, its greatest effect can be produced by end users constructing their own geological data base and checking picture unit by an on-the-spot survey where the comprehensive utilization of picture data is desirable.

There are many advantages of remote sensing from satellite. First, an extensive area can be quickly observed with minimal time required and running cost per unit area. Further, although general information and data, including the geological map, vary in minuteness or roughness and reliability according to their sources, this can be handled under a given accuracy and definition. Accordingly, it is convenient as a standard when integrating and intepreting various data.

In the aforementioned case of Oman, it was instrumental in the comparative study of the two types of geological maps of the same area and was also useful in supplementing the geological map. Further, in case of areas where accessibility is difficult and in countries where it is difficult to take an aircraft, the satellite remote sensing capable of operating by itself has incalculable advantages in conducting geological evaluation.

## SAR Demonstrative Power in Detecting Detailed Topography

At this point the synthetic-aperture radar (SAR) that uses microwave will be mentioned.

Even the recent advanced optical sensor cannot display its full power in areas of cloud cover or dense woods. In this case, the SAR, an active-type sensor of the all-weather type which is also serviceable at night, displays superior capability. Further, since the SAR even permeates vegetation or soil and sand to a certain extent depending on the working wavelength, it displays power in detecting detailed topography which is the basis for interpretive geology. The SAR photo shown here [omitted] is an example of a jungle area in Indonesia, where the characteristics of detailed topography is obscure and cannot be read in an ordinary aerial photograph or optical sensor. The utilization of the microwave radar is supposedly not only to merely complement the optical sensor, but also to open up a new field itself in geological remote sensing. In that case, however, it may be necessary to pay attention to the fact that the image obtained is significantly variable depending on the relative connection between the irradiation direction of radar and the terrain direction.

Today's satellite remote sensing has markedly improved resolution both spatially and spectrally, thereby increasing usefulness in reading geology based on spectral characteristics of detailed topography and rocks. Further, even against the weakness of heavy cloud cover and dense vegetation in the optical sensor, the utilization of the SAR serves more than its purpose as has already been mentioned. It must be taken into account here that in parallel with the progress of equipment and instrument payload of the satellite, unless research and development on image processing technology make the best use of observation results and are not conducted constantly, all efforts will end up as "plowing the field and forgetting the seeds." This develops when hardware and software are united as one, and it is important that it be appraised through the "eyes of the geologist."

## Japan's Observation System and Its Role

The resources satellite ERS-1 now under development by Japan carries the L-band SAR with superior vegetation permeability together with the multiband optical sensor ranging from the visible light and nears infrared region to the short-wavelength infrared region. Further, it is designed to facilitate the reading of geological structure by rendering a stereoscopic function to a part of its optical sensor, which is probably a unique observation system even from the global standpoint. It is probably not just Japan alone that prays for its success in launching and observation work scheduled in 4 years.

It should also be stated in conclusion that utilization of the resources satellite plays an indispensable role in recognizing potential underground resources on the earth. For Japan, which relies heavily on resources from overseas, it is important in the future to constantly investigate and research areas that could supply principal resources. However, it is probably imperative for Japan to consider utilizing satellite remote sensing not only from the standpoint of possibly supplying itself, but also with regard to international relations.

## Developing Materials in Space

Tokyo TSUSANSHO JANARU in Japanese Apr 86 p 26

[Article by Shigeru Maekawa, chief of the Materials Department, Electrotechnical Laboratory, Agency of Industrial Science and Technology: "Materials Development in Space--Toward the Dream of the 21st Century"]

[Text] To this author, who has long been conducting research on electronics, semiconductor, etc., 1985 was the best year to consider the future. This was due to an encounter with space. During the intense heat of August, the author visited the headquarters of the National Aeronautics and Space Administration in Washington, D.C. and the space centers in Alabama, Texas, and Florida, discussing with the engineers and the researchers the possibility of the birth of new materials using the weightlessness in space. During that time the historical inevitability that man's technical development was steadily advancing step by step from earth space was strongly recognized.

Let us now board a space shuttle and fly into space. The forces acting upon substances such as raw materials necessary for conducting material synthesis in the shuttle are the earth's gravity and the centrifugal force of the orbit, and since these forces are mutually in opposite directions, they can be equally balanced. Consequently, the substance in the shuttle is in a condition as if its weight had nearly disappeared. This is known as the state of weightlessness or microgravity because the gravity has apparently become minute. It is said that in comparison with the gravity on the earth, the gravity in the space shuttle decreases to 1/100 to 1/1,000 and that in the unmanned free flier which is attracting attention of late, to as minute as 1/10,000 to 1/100,000.

The most fundamental point in the state of microgravity is that the difference of specific gravity of materials experienced on earth becomes almost meaningless. This is a serious matter. Let us mention an example on earth. When placed in liquid, materials of larger specific gravity precipitate, whereas those of lesser specific gravity float. It is very difficult to mix them together homogeneously in liquid. When a temperature difference arises in the liquid, the phenomenon of heat convection takes place. This is due to the difference of specific gravity between the high-temperature area and the low-temperature area. Also, when a certain substance is taken up, pressure called static pressure acts in the direction of gravity. In crystals, this pressure sometimes causes distortion in the interior, thereby affecting its performance. Above all, liquid does not become stable unless it is placed in a vessel. Under microgravity, however, this type of common knowledge on earth is not applicable. For instance, there is no difference between heavy things and light things, no heat convection nor static pressure, and liquid can be stably maintained without placing in a vessel, and so forth.

These matters have relation with process technology that becomes the basis for synthesizing and manufacturing advanced-technology materials, including

semiconductor materials. Consequently, it may be safely said that microgravity has possibilities as the place to produce a completely new material process technology through the skillful utilization of phenomena unobservable on earth. It was fortunate for this author to have met many people in 1985 who were to challenge this field of the great dream toward the 21st century.

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# MITI'S POLICIES TO DEVELOP BIOINDUSTRY REVIEWED

Tokyo TSUSAN JANARU in Japanese May 86 pp 20-22

[Article by Hirohisa Hiramatsu, chief of the Bioindustry Office, Basic Industries Bureau]

[Text] A new industry called "bioindustry" is expected to be formed in the foreseeable future. However, there are many tasks to overcome before this industry is formed, and therefore proper policies are required.

Biotechnology is a technological area, which effectively uses and applies the biosynthetic and metabolic functions of microorganisms and other living bodies. This is an important technology that has been applied in chemical industries and industries manufacturing fermented products.

The recent, rapid progress in molecular biology and genetics that has identified the structure of DNA, the gene itself, and enabled its artificial manipulation, has led to the development of a new biotechnology with limitless possibilities. This bioindustry will contribute enormously to improving industrial structures and advancing the livelihood of the nation through the supply of new products and effective production processes. This will overcome various problems which human beings will confront in the future, such as resources and energy problems, medical welfare, and food problems.

## Future Prospects for Bioindustry

New biotechnlogy--for instance DNA recombination techniques--is now at the research and development stage, but it will form a large market in the foreseeable future.

A survey conducted last year by BIDEC [expansion unknown] in the Japan Association of Industrial Fermentation estimated that total production by the year 2000 by biotechnology and its related technologies, for instance DNA recombination techniques and bioreactors, will reach Y15 trillion (indicated by 1980 prices). This is equal to the total production value of present chemical industries, which shows that bioindustry will have an important role in and tremendously affect the national economy.

## R and D Trends

In this country, universities and national institutes conduct basic research in biotechnology. Private industries that are engaged in chemistry, medicine, fermentation, and food also take part in biotechology research and development. Furthermore, such industries as oil refining, electronics, and machinery also participate in bioindustry. This shows that various industries have expectations for the future of biotechnology.

The number of applications for patents has risen rapidly since 1979. But applications for patents involving biotechnologies have been geometrically increasing. For example, initially applications for DNA recombination techniques from foreign countries, particularly from America, exceeded those from Japan. The numbers reversed in fiscal 1983. Since then, applications from domestic industries exceed those from foreign countries.

## Policies for Biotechnology

As mentioned above, active studies, from basic research to their application, have been conducted in various industrial areas and in many research institutes.

Although bioindustry is expected to flourish in the 21st Century, there are some tasks to be carried out for its advance: promotion of technical development and arranging an environment suitable to its development as a new industry. Proper measures are required to solve these issues.

While the private sector is expected to develop bioindustries, governmental aid will be required to solve the issues that private industries cannot cope with. Therefore, it is important to engage in these issues effectively and comprehensively by sharing responsibility between the government and the private sector.

MITI is now setting out comprehensive measures to promote bioindustry, which will be mentioned below:

- Planning and Studying General Policies, and Forming the Future Vision

Since biotechnology is a new science, there is considerable uncertainty over its progress in the future. For this reason, proper vision for the future should be based on the latest technical information, and suitable measures should be taken according to the vision.

The "Bioindustry Advisory Committee," consisting of professionals from academic societies and industries, has discussed the definition of bioindustry, the direction to take in the future, and what kind of measures should be taken. The committee made a report in August 1984. Biomass and DNA recombination techniques are being studied by the "Biomass Advisory Committee" and the "Chemical Product Council Recombinant DNA Technology Committee," respectively.

- Promoting Technical Development

Since biotechnology is now at the basic stage of research and development, it must be developed technically. Governmental aid will be necessary for those techniques that will be risky to developing yet important as basic techniques in the future, though how they will be used in the future is not known. From these viewpoints, research and development is being carried out with active use of the various systems for technological development.

1--Research and Development of Basic Technology for Future Industries

This is a system to develop fundamental technologies that will support basic industries in the future, in which biotechnology is contained as one of the three pillars together with new materials and new functional elements. Under this system, research and development on recombinant DNA applications, mass-culture of cells, and bioreactors are jointly being carried out in a long-term perspective by industries, universities, and the government.

Further in fiscal 1986, research and development of bioelements, a junction between biotechnology and new, functional elements, will be started.

2--Development of Biomass-Related Technologies

As part of a series of efforts to develop oil substitutes, it has become essential to establish techniques where ethanol is produced from biomass. Biomass has been attracting attention as a reusable energy resource that does not harm the natural environment. In particular, it has become important to establish production processes for extracting fuel alcohol from cellulose and other resources, such as agricultural waste and used paper. For this reason, studies have been conducted on such areas as cellulose decomposition, fermentation with immobilized enzymes, bacterial fermentation, and isolation of alcohol under reduced pressure.

3. Others

Private research and development, for instance the project to develop an all-round reusable water system (Aquaresaissance '90 Project) and treatment of mineral waste water with the use of bacteria, have been subsidized by expenditures for research that help maintain industrial vitality, and by assistance to research in essential technologies. In addition, protein engineering and other similar efforts are financed by the Fundamental Technological Research Promotion Center started last October to promote research and development in private industries. And affiliated institutes, such as the Fermentation Research Institute and the Chemical and Engineering Institute, have been conducting various research and development programs.

- Arranging Industrial Bases and Suitable Environments

Since biotechnology is a new technology, it is important to arrange proper industrial bases for technical development, and at the same time,

environmental arrangement is also required. Therefore, MITI is now making great efforts to carry out the tasks with the following measures:

1--Securing Biological Resources

It is a prerequisite for biotechnological research and development to secure such genetic resources as different kinds of microbes and cells. This has been done on request from industrial activities and the patent system, as well as academic societies. Further collection and preservation of new biological resources is also important, and MITI has determined to arrange this system in combination with the patent and depository system. Now, the Fermentation Research Institute is going to expand its depository center for patent microbes. When completed, 13,000 strains of microbes and cells (recombinant organisms included) will be preserved.

2--Strengthening the Ties Between Industries, Universities, and the Government

Cooperation between industries, universities, and the government is essential for biotechnological research and development. For this reason, businesses in BIDEC have been actively assisted. The forms of assistance include personnel education business, international cooperation, numerous surveys, and holding symposiums and other meetings. In October of this year, "Biofare '86 Tokyo" will be held, in which a symposium by leading researchers from both Japan and foreign countries, and a large-scale exhibition are expected.

3--Industrial Safety

In order to ensure safety in the use of recombinant DNA technology in Japan, the "Guideline for Recombinant DNA Experiments" was determined in 1979, and experiments have been done following the guideline.

Meanwhile, the Chemical Product Council's Recombinant DNA Technology Committee has studied the safety of recombinant DNA experiments in industrial activities, as such experiments have been frequently conducted recently. In the deliberation, it is considered important to coordinate with the present guideline and the "Guideline for Safety on Recombinant DNA Application in Industrial Activities" worked out in OECD/CSTP.

4--Others

The tax system for activating basic technology research and development is actively used. Surveys to promote research-oriented industries, standardization of reagents and instruments, and promotion of regional technological development are also being conducted.

Promotion of International Cooperation

Research and development for biotechnology is also an important task for foreign countries. Therefore, it is required to conduct effective research by cooperating internationally, while exchanging information on technological

development. For this purpose, international research, industrial cooperation, and the exchange of information have been carried out between Western and developing countries.

For instance, regarding the relationship with developed Western countries, MITI is taking part in dealing various problems in OECD/CSTP: safety, patent, and economic impact. As for cooperation with developing countries, joint research with Indonesia on biomass alcohol, and with Malaysia on effective use of palm oil are being planned.

In addition, MITI is going to propose "The Human Frontier Program," in order to promote basic, creative large-scale research through international cooperation.

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## FUTURE OF ELECTRIC POWER INDUSTRY EXAMINED

Tokyo ZAIKAI TEMBO in Japanese Jul 86 pp 152-153

[Article by Central Research Institute of Electric Power Industry in the "Industrial Topics" column: "Long-Range Research and Development of the Power Industry"]

[Text] The Central Research Institute of the Electric Power Industry (Chief Director Hiroshi Narita) looks at the social and economic situation in the beginning of the 21st century, and is positively advancing the development of technology taking up the problems the electric industry could face in the future by grasping the situations that might surround the electric industry in the future based on this prospect. The subjects of the research will be reported below.

### Three Targets at Which To Aim

The Central Research Institute of the Electric Power Industry, an incorporated foundation, is a consolidated research institute of the electric industry established in 1951. It has about 600 personnel in various specialized fields, and is vigorously advancing research aimed at the following:

--To strengthen the electric power qualitatively to meet the demand for electric power in the future.

--To suppress the supply cost in the electric industry.

--To improve reliability and the understanding of the people toward the electric industry.

### Research Is Being Advanced by Setting Important Subjects

The institute established a "society to study long-range electric power policies" in the institute and is studying problems in the electric industry anticipating changes in society and the economy in 2010 or in 2030 based on a long-range outlook.

Based on these results of the study, the institute is conducting research in the following five important areas in fiscal 1986 taking the changes in recent situations into consideration.

With regard to strengthening the power supply qualitatively, the first of the three targets, the institute is taking up: 1) the nuclear power generation technology which would become the main axis of the energy supply; 2) the technology to expand the use of coal by enhancing clean lines and improving efficient generation; and 3) the technology to transmit electric power more efficiently.

With regard to "keeping down supply costs," the second target, it is studying: 4) improvement of the design and construction method to increase equipment investment and the technology to use the equipment and machinery and tools effectively.

Further, regarding "the improvement of reliability and the understanding of people," it is examining 5) the technology to make the service efficient in conformity with the advanced information age.

In order to exhibit its special capabilities in a consolidated and mobile fashion to cope with the trends of large-scale, interdisciplinary research, the institute is establishing project teams, research promotion committees, etc. Especially, it is strengthening its research system to deal with the fast breeder reactor and the nuclear fuel cycle backup policy and the development of technology for generating coal gasification composite power by establishing project teams under the direct control of the chief director.

Research for Practical Use of Fast Breeder Reactor (FBR)

The FBR, which is said to be the nuclear reactor in the 21st century, is expected to contribute to self-reliance in Japan's energy supply because it can use natural uranium more than 100 times more effectively than the present light-water reactor.

France is already at the stage of operating a 1.2-million kw output, tank type positive reactor of the FBR. The institute believes that even an earthquake-prone country such as ours can construct a 1-million kw class, tank type FBR satisfactorily through the research conducted so far.

At present, it is conducting research aimed at the further improvement of reliability and the decrease of the cost of the FBR.

Attach Importance to Establishment of Nuclear Fuel Cycle

It is important to complete the circle of the nuclear fuel cycle as soon as possible in nuclear power generation, and the electric industry is promoting a plan to construct three plants for enriching, reprocessing, and waste disposal in the Shimokita district.

In order to support this plan positively, the institute has been directing its efforts to positive research on containers for transporting fuel and on the storage and disposal of low-level radioactive waste from nuclear power plants.

Beginning this fiscal year the institute has also been studying in earnest the disposal of high-level radioactive waste produced by reprocessing, etc. in the deep strata by comprehensively utilizing its potential in various fields of research.

## New Stage of Research for Coal Gasification Composite Power Generation

Since the reserves of coal are abundant and the price is comparatively stabilized, it is believed that coal will be used in even larger quantities instead of oil in the future.

In order to utilize coal with high efficiency, the composite power generation method is promising in which coal is gasified at high temperature and high pressure, the gasified coal turns the gas turbine, and its exhaust heat turns the steam turbine.

The institute has developed a gasification experimental reactor based on the water-jet method (2 tons/day) in cooperation with manufacturers and is conducting positive tests. Further, the institute has now completed a dry-type cleanup experimental device, and is conducting combination tests of various desulfurizing and dust collection methods.

This fiscal year, the Technology Research Society, directed by the government, plans to construct a pilot plant (200 tons/day) at the Joban Kyodo Nakoso thermal power plant based on this gasification reactor, and the institute is scheduled to join this society along with power companies and cooperate with it.

## Tackling Further Reduction of Supply Cost

As for cost reduction, the institute has so far been conducting wide research in the rational designing method of the nuclear power plant and the development of a life prediction method for the thermal power generation equipment.

The institute will conduct positive research in cost reduction this fiscal year as well. It is accelerating the R&D of a new economical, safe underground construction method for placing service wires underground, which the electric industry will accomplish earlier than originally scheduled.

Further, power consumption is great in the daytime and is reduced to half after midnight. Therefore, the expansion of the use of electric power after midnight and the effective use of power generation equipment can be considered, which will have an effect on cost.

The institute is promoting the development of a new vegetable factory. The temperature of the factory would be adjusted using ice or hot water produced by the night-time electric power, lighting would be provided by the sun and electric lights, and its environment would be controlled by computers.

## To Cope With Advanced Information-Oriented Society

Society has recently become more and more information oriented, and the exchange of knowledge and technology has become active.

To cope with such a situation, the institute is tackling the development of the Expert system, etc., as a new informational system that would be useful in prevention and security against nuclear power plant accidents and malfunction, and also for entrepreneurs when quick and accurate decisions must be made.

Further, in April this year the institute started the operation of the data base of the Central Research Institute of the Electric Power Industry and the collection of R&D trends and research results in Japan and abroad.

## To Make Research Efficient by International Cooperation

In order to advance the varied R&D, the Central Research Institute of the Electric Power Industry is conducting an exchange of information, joint research, exchange of researchers, etc., in cooperation with 18 institutes of 9 countries, such as the U.S. Institute of Electric Power, to say nothing of related domestic organizations.

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## GOVERNMENT NEW MATERIALS, RELATED DEVELOPMENTS REPORTED

Tokyo NIKKO MATERIALS in Japanese Apr 86 pp 43-45

[Text] High-Temperature Corrosion Resistance Surface Treatment Based on the Combination of Ion Plating and Cementation

The NRIM (National Research Institute for Metals) of the Science and Technology Agency has tried activating evaporated grains by ionizing them, and has tried combining a coated ion plating method with cementation, as a new high-temperature corrosion resistance surface treatment method.

Cementation is a method whereby other elements adhere to the metallic surface, are heated, and diffused in order to give special characteristics to the metallic surface. This method has many merits, such as high-adhesion, no substrate shape restrictions, etc. It is used as a surface treatment for engines to obtain corrosion resistance at high temperatures. However, it is not sufficient, because in recent years, the corrosive environment of heat engines has increased.

For this reason, the NRIM is conducting research on surface treatments obtained by combining the ion plating method with cementation in order to enhance corrosion resistance at high temperatures. As one of the surface treatments, several microns of (Y) yttrium grains were ion-plated on a heat resistant alloy, and subsequently, a concentrated layer of several tens of microns of (Al) aluminum or (Cr) chromium were formed by cementation. The cementation was carried out using a method whereby gaseous hydrogen, with a temperature of 1,100°C, is streamed and heated for several hours in a mixture consisting of aluminum powder or chromium powder, alumina as a sintering inhibitor, and ammonium chloride powder as an activator. As a result, Y was diffused throughout the surface treatment layer in this process, and a composite layer consisting of Y-Al and Y-Cr was obtained. This composite layer had excellent high-temperature corrosion resistance.

Development of Laminar Fine-Powder Graphite

The GIRIO (Government Industrial Research Institute, Osaka) of the Agency of Industrial Science and Technology has developed a laminar fine powdery graphite which will have the effect of filling material. The method for manufacturing such graphite is as follows: Graphite powder is chemically treated, interval layers of localized areas are widened, the volume of the graphite powder is

expanded at a right angle to the plane of layers, and subsequently, the graphite powder is pulverized and arranged. This method possesses a feature whereby the aspect ratio can be selected, extending over a wide range without any restriction by controlling conditions of expansion.

When graphite is anodized in sulfuric acid electrolytes, $HSO_4^-$ ions and $H_2SO_4$ molecules will penetrate at intervals between the graphite layers, and graphite interlaminar compounds will be formed. When this graphite is cathodically reduced, it will be decomposed, leaving a very small amount of penetrating substances, and will be returned to graphite in its almost original crystal structure.

However, substances which cannot be decomposed even by cathodically reducing graphite, will remain between the layers in a metastable state. When these residual interlaminar compounds are quickly heated, they will decompose, interlaminar peeling will be caused by gas pressure generated through decomposition, and expanded graphite with a honeycomb construction will be formed. In addition, this expanded graphite is pulverized with the purpose of obtaining a laminar graphite suitable in thickness and size to the structural wall.

The honeycomb construction wall thickness and the pore size depend mainly on the amount of residual interlaminar compounds before the graphite is expanded. For this reason, graphite powder with an optional aspect ratio can be arranged by controlling this amount in treatment conditions such as anodization and cathodic reduction. On the other hand, the expanded graphite cannot be pulverized by usual methods, because it is a deformable substance, and is as soft as possible when formed. Therefore, the GIRIO has developed and adopted a method whereby after the wall structure is reinforced by cooling and solidifying the surface or the inside wall pores in combination, with benzene, alcohol, water, etc., are mechanically pulverized at the same temperature. Figure 1 shows this pulverizing method. Adsorption layers are thinned, but the thicker the adsorption layers, the easier the expanded graphite can be pulverized. Therefore, it is desirable to adsorb vapor under saturated pressure.

In order to enhance the composite effect, the following physical properties are required: 1) flaky morphology with a large aspect ratio (particle size/thickness), 2) necessary characteristic is anisotropy, 3) dispersion properties which will enhance the filling density and filling effect, 4) lightweight properties for preventing the increase in molding weight, 5) moldability which will reduce the wear of molding materials. The development of filling materials which meet these conditions has been met enthusiastically by relevant industrial fields.

Graphite is a substance with a laminar structure in which hexagonal net planes consisting of carbon atoms are piled up three-dimensionally. This could possibly cause peeling. The elastic modulus, thermal conductivity, and electrical conductivity in the direction parallel to laminar faces are equivalent to or more than those of metal. The elastic modulus, thermal conductivity, and electrical conductivity perpendicular to the laminar faces are very small, approximately one-thirtieth, one-hundredth, and one-thousandth of

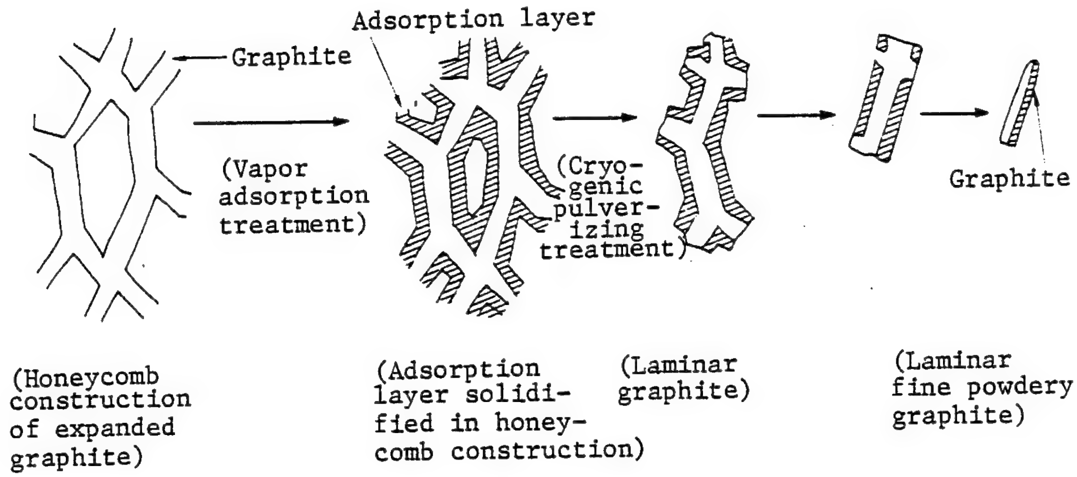


Figure 1. Manufacturing Diagram of Laminar Fine Powdery Graphite

those parallel to the laminar faces, respectively. Also, graphite has excellent chemothermal stability, lightweight properties, self-lubrication, and economic efficiency. For these reasons, the substance explained below has been marketed as colloidal graphite, and has been used as a conductive paint, mold releasing agent, etc. This substance is manufactured by finely pulverizing natural phosphoric graphite to 0.1 to 10 microns and by suspending the pulverized graphite in a fluid dispersion.

Recently, fine-powdery graphite has been used increasingly in various fields. For example, circuit substrates manufactured by printing graphite on insulating substrates, have spread to electronic parts. But it is difficult to control the shape of particles because most of the fine-powdery graphite on the market is manufactured using a mechanical pulverizing method. For this reason, the graphite can only be arranged in an aspect ratio of about 10 to several tens, at most. This is a disadvantage of graphite.

The GIRIO has established technology for manufacturing laminar fine-powdery graphite which will meet conditions as a filling material. It has disclosed that laminar fine powdery graphite with an aspect ratio of 300 can be obtained from the expanded graphite with an expansivity ($L/L_0$) of 300 to 350. It has also been clarified that laminar fine-powdery graphite can be arranged so the graphite retains a range to reach the aspect ratio of 700, by selecting manufacturing conditions such as the expansivity, the adsorption of vapor from the expanded graphite with a honeycomb construction, etc.

It is said that this material will be useful in obtaining high-performance heating elements, electromagnetic wave shield housing, printed circuits, etc. because it is expected that the material will have high-conductivity and high-orientation. In order to make good use of such material, various surface treatment technologies must be developed in the future--for example, technology for graphitizing functional groups of graphite layers, with the

objective of enhancing dispersion properties and technology for metal coating in the graphite layer which will lower contact resistance.

Surface Treatment of Carbon Fiber for FRM

The No 1 Material Development Division of the GIRIK (Government Industrial Research Institute, Kyushu) of the Agency of Industrial Science and Technology is studying the high-melting point metal such as tantalum, molybdenum, chromium, nickel, etc., and the ceramic coating effect of tin, etc., as part of research on surface treatment of carbon fiber for FRM (fiber-reinforced metal).

These high-melting point metals are based on an ion plating technology, and the ceramic coating effect is based on a reactive ion plating technology or a plasma CVD (chemical vapor deposition) method. The composite material has come into the limelight as a new material in the metallic material field because of the demand for lightweight and high-performance materials. Particularly, the FRM is greatly anticipated, because of its light weight, heat and weather resistance, and high-strength and high-elastic modulus. But, it has not been put into practical use in proportion to the great expectations and efforts of its developers. This is because a problem in adaptability has not been sufficiently solved. This bad adaptability problem lies between the base metal and the fiber used in the FRM. Even the CFRAl (carbon-fiber reinforced aluminum) which is scheduled for use in the near future, has problems with bad wettability and bad adaptability which have not been solved yet. This bad wettability lies between carbon fiber and aluminum. This bad adaptability lies in its reaction to high temperatures. Bad wettability will cause bad adhesion as well as difficult moldability. Therefore, stress cannot be propagated sufficiently between fiber and metal, and no composite effect can be obtained from dynamic characteristics such as strength, etc. Also, reaction at high temperatures will form a fragile intermetallic compound ($Al_4C_3$) on interfaces, and will lower the strength of carbon fibers. Therefore, the expected strength of composite materials cannot be obtained.

For the above reasons, it is necessary to improve the adaptability of carbon fiber to aluminum. Methods of improving the adaptability can be broadly classified into the following two kinds: 1) alloy elements are added to aluminum; 2) carbon fibers are coated in the third phase. This third phase has excellent adhesion and wettability with aluminum, and constitutes a reaction barrier. With regard to item 1), it is said to be effective to add silicon, copper, magnesium, iron, etc., to aluminum, but no fundamental method has been developed. Most research on methods of improving adaptability are related to item 2). The Material Development No 1 Division is conducting research using the coating method.

Photograph 2 [omitted] shows a high-strength carbon fiber based on PAN (polyacrylonitrile), a carbon fiber containing tantalum coated by ion plating technology, and a carbon fiber containing tin coated by the plasma CVD method. This photograph is taken using an SEM (scanning electron microscope). The entire carbon fiber can be coated uniformly, because using the plasma CVD

method will cause a gaseous reaction. Also in the case of ion plating technology, the film thickness of carbon fiber deposited from its front side is different from that deposited from its rear side; most of the carbon fiber can be coated uniformly by coating it from both sides.

With regard to evaluations concerning surface-treated carbon fiber which has an effect on adaptability to aluminum, the wettability and adhesiveness are being evaluated on the basis of results obtained by performing simultaneous experiments employing graphite substrates. With regard to wettability, the angle of contact between graphite substrates and aluminum droplets is measured in a vacuum. Regarding adhesion, an aluminum plate is put in the interval between the coated end faces of graphite substrates, is maintained for 30 minutes at a temperature of 700°C, and is fused-joined while in a vacuum. Subsequently, the adhesive power of the interface is evaluated on the basis of results obtained by performing a tensile test of the aluminum plate. On the other hand, a single-fibrous composite material is heat-treated for 5 hours in a vacuum. Subsequently, the deterioration of fibers, caused by interfacial reaction is evaluated on the basis of results obtained by tensile tests on this heat-treated composite material.

The single-fibrous composite material consists of aluminum, surface-treated carbon fiber, and carbon fiber manufactured by further coating aluminum with surface-treated carbon fiber. The table shows the effect of surface-treatment, given the adaptability of carbon fibers to aluminum. These carbon fibers have been clarified up until now. $\theta_{800}$ is an angle of contact between a graphite substrate and aluminum at a temperature of 800°C. The adhesive power between the graphite substrate and aluminum is B. $\delta$ is the tensile strength of the fibers. Also, 0 which is an attached figure means a surface treatment condition, 600 means after-heat treatment at a temperature of 600°C, and $\chi$ means a composite material consisting of aluminum and single-fibrous carbon fiber.

The poor wettability and poor adhesion between graphite and aluminum can be sufficiently improved by carrying out heat treatment, but a method effective in preventing fiber deterioration, has not yet been established. This deterioration is caused by interfacial reactions. Research on ceramic coating based on a reactive ion plating technology will be continued in the future.

Adaptability of Surface-Treated Carbon Fiber to Aluminum

| Coating | $\theta_{800}/°$ | B/kg·mm$^2$ | $\sigma/kg \cdot mm^2$ $\sigma_0$ | $\sigma_{600}$ | $\sigma_0^*$ | $\sigma_{600}^*$ |
|---|---|---|---|---|---|---|
| No | 148 | 0.37 | 318 | 310 | — | — |
| Al | 72 | 0.87 | — | — | 311 | 128 |
| Cu | 35 | >3.4 | 291 | 308 | 329 | 56 |
| B | 90 | >2.9 | 204 | 93 | 267 | 84 |
| Ti | 35 | >2.0 | 262 | 139 | 277 | 49 |
| Zr | 81 | >2.4 | 263 | 196 | 262 | 70 |
| Si | 73 | >2.6 | 286 | 176 | 253 | 98 |
| Ta | 150 | >2.9 | 216 | 101 | 196 | 97 |
| Cr | 5 | >2.4 | 183 | 106 | 166 | 90 |
| Mo | 94 | >2.3 | 253 | 141 | 200 | 76 |
| Fe | 3 | >2.1 | 254 | 132 | 234 | 78 |
| Ni | 13 | >2.4 | 230 | 146 | 253 | 105 |
| TiN | 143 | >3.1 | 298 | 92 | 318 | 111 |

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# ASAHI GLASS DIVERSIFIES THROUGH NEW MATERIALS

Tokyo TSUSAN JANARU in Japanese May 86 pp 80-82

[Article by Kaoru Maki]

[Text] The 21st Century is just around the corner. What enterprises will have the strength to meet the challenge of the coming century in some 10 years time? It is not easy to foresee the prosperity and decline of enterprises in the kaleidoscope of political, economic, and social change. However, it is obvious that current enterprises of good standing must absolutely have an earnest positiveness and definite objects supported by foresight in order to maintain their existence in the coming century. It will soon be 80 years since Toshiya Iwasaki founded the Asahi Glass Co., Ltd. and turned all his passion to the domestic production of flat glass. Asahi Glass is the largest glass manufacturer in Japan, and has a long and glorious history. This company has been successively making preparations to enter fields that will grow in the coming century without contenting itself with its present high income level. This reflects the management philosophy of Takeo Sakabe, the president of the company--a philosophy aimed at developing the company in the 21st Century.

## Positive Developments in Electronic Fields

Last August a refined and reinforced four-storey concrete building was completed by the Asahi Glass Co.'s Research and Development Division in Hazawa-cho, Kanagawa-ku, which is in the center of Yokohama-shi. The name of this building is "The Asahi Glass Electronic Products Development Center." Although the organization of this center is different from that of Asahi Glass the center is a base for carrying out research and development work in electronic fields. Asahi Glass expects that the center will become a means to diversify the company's business. New building materials--such as heat reflecting glass, fluorine plastic paint, etc.--developed independently by the company were used abundantly in the construction of the center. Iwao Ouishi, ex-vice-director of Japan Broadcasting Corp.'s Science and Technical Research Laboratories, was named to head the center. About 120 employees, including engineers recruited from the outside, are engaged at the center. Asahi Glass has shown a strong interest in electronic fields both inside and outside the company.

Asahi Glass has progressed steadily for the past several years by full scale participation in electronic fields as well as by establishing the center. One of the reasons for this is that the company started commercializing thick-film printing products for hybrid integrated circuit's under joint management with Nippon Carbide Industries in March 1984. Asahi Glass has developed circuit design technologies and has experience in various electronic fields. Nippon Carbide Industries has ceramic-forming technologies and circuit pattern printing technologies. The purpose of this commercialization work is to enhance technologies related to semiconductors by uniting their combined experience and technologies.

In addition, in August 1984 Asahi Glass bought a 26.3 percent interest in the Elna Co., Ltd., a printed wiring board manufacturer that was under the control of The General Corp. Accordingly, it has been decided that Asahi Glass will procure electronic parts and that Elna will be in charge of the production and assembly of printed boards. Asahi Glass has been directing its energies particularly to products related to the semiconductors used in the electronic fields tackled positively by the company. It can be said that the business foundation of these products has been steady.

The second aspect of its electronic business is the creation of a department to handle electronic displays. Asahi Glass has established the Optolex Co., Ltd. under a joint management arrangement with Mitsubishi Electric Corp. While Optolex manufactures and sells liquid crystal displays, Asahi Glass is in charge of all research and development of such liquid crystal displays. The technologies of Asahi Glass in the field of liquid crystal displays are among the best in the world.

The company's third business is related to optoelectronics, that is, the research and development of optical fibers. Asahi Glass is steadily conducting research on short-distance optical fibers for local area networks and computer wiring, with the aim of commercializing them. Also in August 1984 the company joined forces with Tokyo Denpa Co., Ltd., which is a large manufacturer of quartz crystal resonators, and participated in the manufacture of artificial quartz crystals. This is because Asahi Glass was conscious of developments in the electronic field.

Concentration of All Energies on New Materials and Biotechnology

Asahi Glass Co.'s new business involves not only electronics. The flat glass department has been traditional since the company was established. The soda ash and other materials used in glass melting furnaces were required as raw materials for manufacturing the flat glass. Their current lines of chemicals and ceramics have grown from this earlier manufacturing work. And now, new products supported by state-of-the art technology in both fields, are being manufactured. With regard to the technology related to ceramics, Asahi Glass has early and independently developed a pressureless sintering method. This method is used to produce a range of minute, high-strength, complex, and large ceramics through the use of silicon nitride and silicon carbide powders. The company has paved the way for the ceramic engineering world.

Following on from this development work, the company succeeded in developing a ceramic based on zirconium boride in the autumn of 1984. This ceramic is a revolutionarily new product. As an electrically conductive ceramic, it can be precisely worked by using an electric discharge machine. It has increased the company's sales since Asahi Glass started mass producing it last year.

With regard to chemicals, whatever else may be said, fluoric chemistry constitutes one of the company's principal departments. Fluoric chemicals are extremely resistant to heat, chemicals, etc., and are typical of fine chemistry. The company has a wide range of products, such as fluorine plastic, fluororubber, fluoric paint, etc., and has developed a highly regarded ion-exchange membrane for manufacturing caustic soda. In addition, the company has been directing its energies toward the development of a new technology obtained by combining fluoric chemistry with biotechnology. And the company is seeking to develop wonderful new chemicals by synthesizing new substances through the new technology. Judging from all this, it is obvious that electronic new materials, and biotechnology serve as great new business fields for Asahi Glass as it faces the 21st Century. It can be said that this reflects the company's earnest desire to change from a maturing top glass manufacturer to a composite high-technology enterprise in the 21st Century.

Foundation Is Consolidated With Composite Diversification of Business in the 21st Century

Export industries, such as automobiles and electronics, have been hit by the recent sharp appreciation of the yen. This in turn has started to affect Asahi Glass, which supplies parts to these industries. Although the business results of the company at the settlement of accounts in December 1986 can not be predicted, the actual results of the company for the past several years are remarkable. The company recorded Y504.9 billion in sales in 1984. Subsequently, the company steadily continued to increase its sales, recording Y676.8 billion in 1985. The company also increased its ordinary profit from Y40.6 billion to Y57 billion in the same period. Therefore, it can be said that the company has been operating fully as an enterprise of very good standing.

The company has continued consistently to advocate diversification since Hideaki Yamashita took his place as chairman and Takeo Sakabe was inaugurated as president in March 1981. This is because the philosophy of management, "An enterprise structure that will be prosperous in the 21st Century," has taken firm root in the company's policy of diversification. Company President Takeo Sakabe has steadily refined his idea of multilateral management strategies. These multilateral management strategies have been mapped out over the 80-year history of the company. The first term was a period beginning with its establishment to around 1930. The company succeeded in commercializing flat glass for the first time in Japan during this first term. In this period, the company set the flat glass business on its way by automating the supply of furnace materials and soda ash, which is a raw material used in flat glass.

The second term came in the postwar period. In this period, the company branched positively into fields related to flat glass on the basis of the business that had been established prior to the postwar period. That is, the company branched out into fluoric chemicals, using the chlorine that is produced together with worked glass, valve glass, and casutic soda, following on from the flat glass.

President Sakabe describes the first term as the "vertical diversification of business" and the second term as the "horizontal diversification of business." He emphasizes the necessity of a "composite diversification of business" for the purpose of promoting an "enterprise structure that will be prosperous in the 21st Century." These include glass and chemistry, composite materials combined with ceramic technologies, development of system goods produced by combining captive materials and electronic technologies, composite combination of technologies and products for developing these system goods. Also, the president insists that we should increasingly promote new and growing business fields such as new materials, electronics, and biotechnology by taking managerial resources from the outside as well as internal managerial resources.

In addition, the company intends to streamline the business of the whole Asahi Glass group by taking partial charge of business functions of relevant companies, reinforcing the mutual exchange between Asahi Glass and these relevant companies, and reorganizing the structure of Asahi Glass itself. When the president asks the employees for understanding and cooperation for its policy "diversification of business" in the third term, he points out that--looking at individual enterprises in the vicissitudes of industries--it is said that enterprises will shut their doors in 30 years unless they take positive measures to meet the coming situation. He also stresses that only our positive promotion of diversification will ensure survival in the 21st Century, noting that there is no doubt this trend will be intensified increasingly.

The company's share of the domestic market for flat glass is less than 50 percent, and that of the world market for valve glass for television is 30 percent. Asahi Glass is an oligopolistic enterprise that has more than 10 products glass and chemical that enjoy top domestic share. In addition, the company has no anxiety for the future. But looking back on the history of the vicissitudes of industries, the company must recognize a grim reality, "nothing ventured, nothing gained." Could it not be said that Asahi Glass has consolidated the foundation of the business to meet the 21st Century, when the earnest positiveness of the president who asserts the proverb has taken firm root in the mind of 10,000 employees?

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PROSPECTS FOR FINE CERAMICS INDUSTRY ASSESSED

Tokyo NIKKO MATERIALS in Japanese Jun 86 pp 20-23

[Article: "Open Forum on Ceramics and the Material Industry"]

[Text] It has been 5 years since fine ceramics first appeared as materials with industrial applications. They created a great sensation as materials for the coming century, with many hoping they would prove to be of the greatest value.

However, when it comes to talking about the actual condition of fine ceramics, especially for that for engineering ceramics, persons in charge of new material development are greatly concerned about the extent to which the funds, manpower, and risks invested in their development are actually producing returns.

The Society of Polymer Science, Japan, consisting of a group of ceramic researchers, held an open forum entitled "Ceramics and the Material Industry." It was held with the idea that prospects for industrial and technical development could hardly be considered without positioning new materials. Here is reported the present situation regarding new material development with a focus on what was discussed at the forum.

Fine Ceramics, New Industry

Professor Hiroaki Yanagida of Tokyo University served as coordinator of the forum. In the beginning, he gave a briefing on current issues.

He said: "It is generally said that new materials are booming and material manufacturing companies not engaged in new materials are now in management difficulties. Some are worried over how to participate in the new material field. Others, even if handling new materials, actually do not seem to have sure footings. Many of them are suffering from the dilemma."

Then, Professor Noboru Ichinose of Waseda University, a former researcher of electronic ceramics for Toshiba Corporation, described what new materials and the new material boom were like.

"It is quite difficult to define new materials. Frankly speaking, according to the definition of new materials given by manufacturers, they are small in quantity and high in added value, being sold by not weight but by the gram."

As for the ceramic boom, Shoichiro Fujimoto, director of the Kurosaki Ceramics Co., Ltd., said: "It is like a fever." Many people view the boom as a fever. Furthermore, Kiyoshi Sugita, councilor for Shin Nittetsu Co., Ltd., analyzes the current boom as follows: One-third of this boom is hilarious, another one-third is uncertainty, and the remaining one-third is reliable with bright prospects.

At this point, Yoshihiro Adachi, office manager of fine ceramics for MITI, spoke: "I wonder if it is not always necessary to compare old materials with new materials. The new material business is simply a reinforcement of management for the steel and cement companies. MITI is thinking about where and in what form material industries should be placed in Japan's industrial structure in the future. This question is so big it will determine what Japan's industrial structure will be."

He added: "Meanwhile, the new material industry is new and growing. A current issue is how to develop new markets. A view of new materials as something to replace old materials is wrong." He emphasized that new materials create a new industry and it is not necessarily expedient to think of them as linked to old materials.

Jozo Toda, chief researcher for Hitachi, Ltd., spoke from the standpoint of a user: "The key point of ceramics rests in the profit that can be made from them in the end, rather than how to make them. In other words, end products containing ceramics are the main question for manufacturers. They change rapidly with improvements in people's living standards, and materials also change in response to changes in people's lives. The most important thing is to develop new materials from which many industries will benefit. For example, the use of silicon wafers has been extended to many different industries, including raw materials, chemistry, vacuums, evaluation, etc. If materials are profitable to the ceramic industry only, their use is very limited." He is hoping for the advent of new materials beneficial to everybody.

Not Ready for Immediate Business

By the way, what motivated many enterprises to participate in the new fine ceramics industry and what are the results?

Kengo Morita, head of the Onoda Cement Ceramic Development Institute, said: "We have found our way into this new industry of fine ceramics. Through ceramic engineering, we are making the best use of the thermal, powdering, and baking techniques cement companies have long employed. Our company as a whole is now ready for support, but we are faced with many problems such as how to connect research and development with commercial business and how to secure large funds for research. Consumers are increasingly demanding fine ceramics of such high grade and great diversity that production must be of

the many-in-variety-and-small-in-production type. In this condition, fine ceramics emulate metallic and other materials." He said that he felt fine ceramics were costly.

Fujimoto, director of the Kurosaki Ceramics Co., Ltd., said: "There are signs that the manufacturers of fire-proof materials are joining in the new fine ceramics industry all at once. This is because the fire-proof material manufacturing industry depends on the steel industry for 70 percent of its business, but any growth that can be expected in Japan's steel industry will demand that the fire-proof material manufacturing industry participate in a new business. Therefore, it is said that fear of a future business crisis has compelled the fire-proof material manufacturing industry to enter the new business of fine ceramics."

He continued: "However, it is questionable how much the fire-proof material manufacturing industry has grasped true needs before entering the new business. In the area of electronic ceramics, true needs can be easily seen. However, engineering ceramics have just taken a fresh start with many points of uncertainty about where to go. Products with such characteristics cannot find quick sales as anticipated, even if developed. In general, as is often the case, the aim of developing new products is to replace existing materials, but the problem of price presents a hazard."

Professor Ichinose of Waseda University talked about his experience during his service at Toshiba Corporation:

"At Toshiba, I conducted sensor-centered research. Sensors are so difficult to commercialize because they cannot be connected immediately with business. Furthermore, research and development involves large amounts of money and much time. Even if products are developed, they do not always meet with quick sales. However, there are hopes that a new industry will be created by a chance hit, after they have been placed on a commercial basis successfully. Anyway, the most important thing is to meet a target with true need."

Meanwhile, Asahi Glass Co., Ltd., may be one of the few enterprises enjoying smooth progress in the business of fine ceramics. It entered the business of ceramic engineering on a full scale 4 years ago and is experiencing a year-to-year doubling of the business, even if this is not as much as anticipated. This high-rate growth is expected to last for 3-4 years to come.

Shiro Takahashi, executive director of the company, said with a show of confidence in the future of the business: "The key to the ceramic engineering business rests in distinguishing between our end user and our competitor. To know our end user is to grasp the true need of our end user."

Shin Nittetsu's Way of Thinking

The champion of the old materials industry is, whatever others may say, the steel industry, which now stands at a crossroads. Steel production is so well matured that the growth of the steel industry can be anticipated.

Steel is, in many cases, exported directly or indirectly, and the steel industry is typically export-oriented. What will be the ill effects of the yen's steep appreciation and its fixation? Furthermore, industrial history tells us that an industry moves inevitably from west to east. It is a matter of time before the steel industry moves to medium and less developed countries.

Sugita, counselor for Shin Nittetsu Co., Ltd., said: "The iron age will last longer. The steel industry is said to be well matured. However, its production is on the increase little by little and potential demand for iron is enormous. The steel manufacturers in Japan are using production techniques to bring costs down and are making products of high added value which only they can make, and in response to internationalization they will export capital."

However, the fact is that steel manufacturers are keen on diversifying their business in anticipation of future prospects. Even if the lines of diversification they take are different from one another, their major themes are engineering, new energy, chemicals, and new materials.

Counselor Sugita said: "Steel companies have accumulated a variety of techniques and human resources both directly or indirectly. Ceramics are one of the key points when considering the new material business."

Material manufacturers in general harbor some sense of terror about the advance of steel manufacturers into the fine ceramics business. This is because material manufacturers are no match for steel manufacturers in terms of human assets, techniques and capital--the three major management resources in the development of a new business, even if it is unknown until a new business is developed.

Counselor Sugita explained Shin Nittetsu's thinking about its participation in the new fine ceramics business as follows: "The four points of Shin Nittetsu's ceramic business are: 1) The business should be long-lasting. 2) It is highly profitable. 3) It can foster as many men as possible. 4) It creates products good enough to be competitive in the international community."

As might be expected of a big enterprise, he continued, "ceramics are said to involve a wide range of techniques, and when analyzed in terms of technology, they cannot be covered by talented persons in material engineering and material science only."

## No Dialogue With Users

Enterprises have taken part in the business of fine ceramics on their own motivation and inevitability. However, it is still too early to say that the business is profitable. Participation itself is risky, but at the same time there are many problems a single enterprise is unable to solve.

Here are some examples of this:

--Nothing can be heard from an end user about materials or manufacturer's supply. This serves nothing but to delay the settlement of a problem.

--Data bases have yet to be arranged for material designs.

--Generally, there are many cases where companies ask that ceramics be made on the basis of metallic design. In such cases, ceramics are disadvantageous in terms of cost. If an end user devises designs that are easy to make using ceramics, then cost becomes less.

--The need for original ceramic designs is a theme often heard everywhere. However, it seems to take a long time before the gap between metals with a long history and ceramics, which are brought into being as a new science, is filled.

--It has been long pointed out that no dialogue is exchanged between researchers on the manufacturers' side and those on the users' side. It is not known whose fault this is. Perhaps, researchers on the manufacturers' side are in fault, or maybe those on the users' side are wrong, or both sides may be guilty. New materials are products developed in a common area of many scientific boundaries and their industrial applications cannot be realized without the cooperation of researchers in many different fields.

From Raw Materials to Parts

Fine ceramics, apart from the generally prevailing fever phenomenon, are making steady headway in a struggle against risk throughout Japan. What will determine their future course?

Director Fujimoto of the Kurosaki Ceramic Co., Ltd., said: "Honestly, the new material business is having a pretty hard time. As a matter of fact, the existing business is being reinforced, instead of a new business being developed. This has a positive effect on recruitment activities as well. The development of new materials comes in an age where research must be carried out from the very beginning. There are some fears that the funds for development may not be collected. However, I feel it necessary to spread them all the way from their points of departure to their points of destination."

Institute head Morita of the Onoda Cement Co., Ltd., is of the same opinion in that new materials must be end user-oriented.

He said: "It is necessary to develop parts using new materials derived from raw materials. The development of new materials can move forward persistently from its infancy, despite the trouble caused by the inability to grasp needs clearly."

Furthermore, it is agreed that what necessarily lies behind a new industry are persons of excellent ability and not those who have specialized knowledge

of ceramics only but those who are versed in electronics as well--in other words, multifunctional men are required. Another desired thing is to strengthen the combined efforts of industries and universities, not only to obtain new ideas but to speed up research and development.

Counselor Sugita of Shin Nittetsu Co., Ltd., said: "The motto of cooperation between industry universities exists only in Japan. This is nothing new in other countries. The social milieu of Japan does not allow basic research to take root deep into the industrial circle, for Japan's industries are firmly set on development and applied research. However, now is the time for basic research. To conduct basic studies is like a tax on the advanced countries."

Executive Director Takahashi of Asahi Glass said: "Even in Japan, we will set to work on basic studies for years to come, and we wish to pin many hopes on universities, including talent-rearing."

In Japan, fine ceramics have reached the stage where the fruits of researchers' steady efforts have produced materials with excellent physical characteristics and its processing and evaluation techniques are highly regarded. However, they have not yet reached a point where they yield profits. Management's awareness of ceramics for the most part is that they are still in the process of investment and cannot be used to bring profits in a hasty manner. The "ism" of "research and development first" will last for some time.

Accordingly, the choice of a theme for development by researchers will influence the future of ceramics. Are there any methods that facilitate this choice?

Professor Ichinose of Waseda University said this: "Manufacturers are all the same or very similar. The market for fine ceramics is very limited. Japan's power to research and develop what lies beneath can be properly evaluated, but it is no good for enterprises to play a game of excessive competition with one another in a very limited market."

His statement hits the mark. In the past, Japanese enterprises have used such criteria to determine product development and new business development as A company and B company are forwarding such and such a plan, so, our company must do so too. Horizontal ways of thinking, meaning to evade risks, are also used. Such criteria are suitable for Japan's homogeneous society. However, this old way of thinking will not work well for Japan's enterprises whose technical development has now moved into an unexplored area. The day is awaited when product development and new business development are carried out on the basis of original concept, and not the concept of mimicry.

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# PRESENT, FUTURE OF ALCOHOL-FUELED ENGINES

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[Article by Masahiko Hori and Eikichi Kin, Japan Automobile Research Institute, Second Department: "Present and Future of Alcohol-Fueled Engines"]

[Text] 1. Preface

Since the Ministry of International Trade and Industry [MITI] has started research and investigation in relation to the application of alcohol fuel to automobiles, research related to alcohol fuel, for which the basic study had so far been performed by universities and institutes, has developed to the feasibility study supported by related industries on the premise of practical application. As a result of 3 years of investigation, it became clear that if medium alcohol mixture rate gasoline, such as 15 volumetric percent methanol mixed gasoline (M15), is applied to the present gasoline automobile, problems occur as difficulties arise as to exhaust gas and operability at normal and high temperatures, as well as deteriorated fuel system components. In relation to the low alcohol mixture rate gasoline, only few data are available domestically as well as abroad, and a feasibility study in relation to 3 volumetric percent methanol mixed gasoline (M3) is now being performed.

Based on the results of several years of basic research from 1973, JARI [Japan Automobile Research Institute] obtained grants from the Agency of Industrial Science and Technology [AIST] of MITI in 1980, and started research for application and practical development in relation to neat and near-neat application of methanol. The research was aimed at development of a prototype of the reformed methanol gas engine for passenger cars, of a methanol/gas oil dual fuel injection system engine for medium class automobiles, and of vehicle systems. Moreover, R&D of a reformed methanol gas engine for large vehicles was started in 1983.

Further, the Ministry of Transport announced in June 1984 a fleet test project for popularization of the methanol vehicle aimed at reduction of urban pollution such as NOx and versatility of transportation fuel. The new project resulted in the need for a review of MITI policy which has been proceeding with a feasibility study of alcohol fuel, and the Agency for Natural Resources and Energy organized a Vision on New Energy Introduction in June 1985. With this scenario, related industries, including the automobile, oil, and transportation industries, are required to draft new countermeasures.

Table 1. Status of Development of Alcohol Fuel Application Technology

| Classification by application technology | | | Type of research, step of development: ① Basic research (Bench test of engine) Basic research on combustion method, fuel supply method, exhaust gas cleaning method, lubrication method, engine starting method, etc., using single-cylinder engine, to look for the optimum condition of methanol engine | ② Application research (Dynamo test of engine) Study of applicability to practical engine Refining of multicylinder system | ③ Development research (Chassis dynamo test) Study of applicability and practicability as vehicle system Performance, exhaust gas, drivability of vehicle | ④ Feasibility study (Practical running, fleet test) Confirmation of adaptability and practicability from the face of durability, reliability, safety, and social demands (pollution) | ⑤ Merchandizing research Research to obtain high degree of merchandise, quality, reliability to meet market requirements |
|---|---|---|---|---|---|---|---|
| Substitution for gasoline | Neat/near-neat application method | Carburetor system<br>Homogeneous method, Injection system {Turbo, NA} | | | | | G1 |
| | Carburetor system | Laminar feeding method | | | | | |
| | Neat application/reforming method | | | G2 | | | |
| | Others | Mixed application | | | | | |
| Substitution for diesel oil | Fumigation method | Carburetor system<br>Injection system | | | | | |
| | Near-neat application method<br>Dual fuel injection method | 2-pump, 2-injection system {Swirl chamber, Prechamber, Direct injection} | | | | D1 | |
| | | 2-pump, 1-injection system | | | | | |
| | Neat applying, forced ignition system | Spark assist system: Cylinder injection {Swirl chamber, Prechamber, Direct injection}; Premixing<br>Auto-ignition method | | | | D2 | |
| | Neat reformation system | Neat application, fumigation | | D3 | | | |
| | Others | Ignition accelerator addition system | | | | | |
| | | Mixing application | | | | | |

This paper intends to summarize the domestic, as well as foreign technology, of alcohol fuel application, and also to describe views on technical tasks and their future.

## 2. Present Status of Alcohol Engine

Table 1 indicates the status of development in relation to alcohol fuel application technology. The homogenizing method as a substitution for gasoline has left a relatively small element of development in the field of engine technology, and the work is concentrated on the task left for merchandizing. The reformation process has advantages such as recovery of exhaust gas heat and dilution of mixture by mixing reformed gas ($CO$, $H_2$). However, many related technical tasks are yet to be solved in relation to the reforming equipment, controller, etc.

As for the application technology to substitute for diesel oil, the technical development for a dual fuel injection system and a forced ignition system are progressing, and part of them are being applied to street buses. The reformation method has combustion difficulty in addition to the same task as required in the case of substituting gasoline. Therefore, it is a more difficult technology, and many further R&D efforts are required.

Many other applications are at the basic research level and many tasks are yet to be solved before practical application is feasible. Among them $G_1$, $D_1$, and $D_2$, on which technical studies are advanced and are in a relatively high degree of completion, and $G_2$, which is expected as future technology, will be explained while other application technology is to be described at a later time.

### 2.1. Gasoline Substitution Application Technology

#### (1) Neat/Near-Neat Application System (Homogeneous Method)

Work on this system is most abundant, and the level of completion for application technology is also high. Ford in the United States and Volkswagen (VW) in Europe are positively proceeding with the research, and GM and Benz are following. In Japan, Toyota and Nissan have published reports on their work, and Mitsubishi and Mazda are also working on the research.

Ford has been working on the practical application of alcohol fuel since 1974. The starting performance of the neat methanol engine is not satisfactory, and 5.5 volumetric percent of isopentane was added for improvement. Further, 10 volumetric percent of gasoline has been mixed since November 1982. Recently, however, the rate of gasoline mixing was increased further, and near-neat methanol mixed with 15 volumetric percent of gasoline (M85) is being used. It is said that to ensure visibility during firing is one reason for such addition.

Ford is offering more than 500 methanol fleet cars (Escort, 4-cylinder, 1.6 liter) to public organizations, including CEC (California Energy Commission).

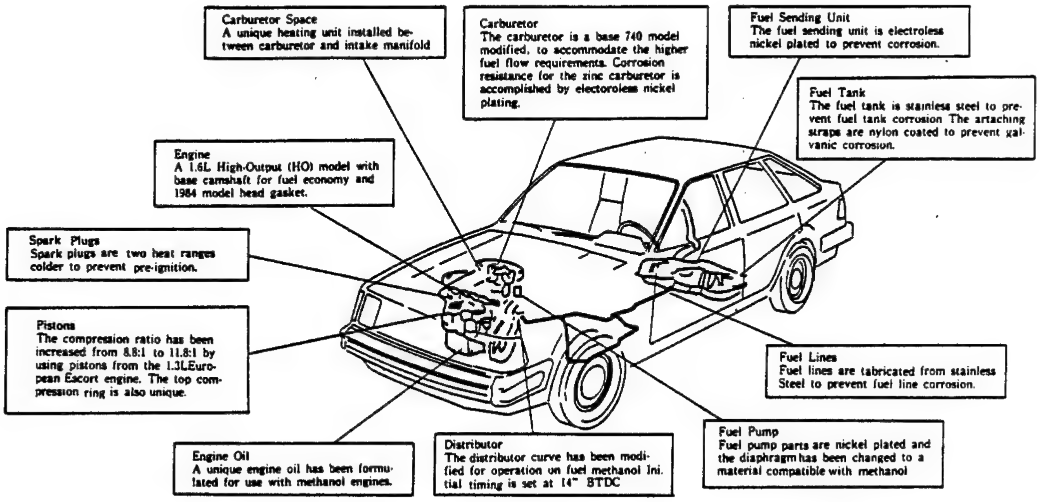



Figure 1. Major Replaced Components for Methanol Specification Escort

Engine components and materials are modified for these cars. Figure 1 indicates the major points of modifications. The compression ratio of the engine was changed from 8.8 to 11.8, and the spark plug was changed to a colder type to prevent knocking and preignition. As for the fuel system, materials for the fuel tank, piping, and carburetor were replaced with methanol resisting materials.

Toyota has studied a vehicle with dual fuel systems, methanol and gasoline. Figure 2 gives the system drawing which uses gasoline at engine start and changes to methanol after the engine is warmed up. When ambient temperature is -10°C or lower, self-operation of the engine cannot be done by feeding gasoline only when the starter is operated. Therefore, gasoline is fed for several seconds after the engine is started. By adopting this system, starting characteristics of the gasoline at -20°C could be made the same as that of the gasoline engine.

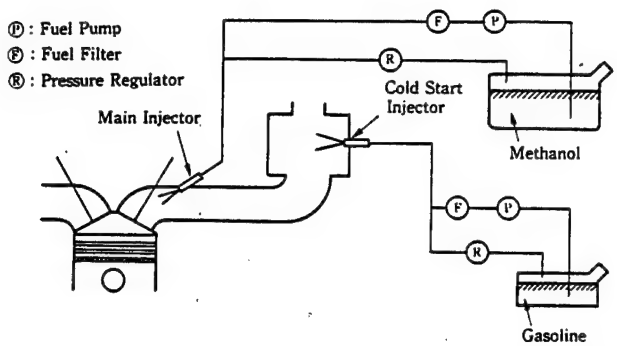



Figure 2. Toyota's Dual Fuel Engine System

Table 2. Exhaust Gas of Methanol Vehicles

| Operation mode | Name of car | HC | CO | $NO_x$ | HC+$NO_x$ |
|---|---|---|---|---|---|
| FTP | Ford Escort g/mile<br>1981-82 California regulation | 0.11<br>(9.41) | 1.32<br>(7.0) | 0.44<br>(0.70*,0.40) | |
| | Ford Escort g/mile<br>1983 California regulation | 0.34<br>(0.39) | 1.76<br>(7.0) | 0.61<br>(0.70*,0.40) | |
| | AMC Concord (Baltimore fleet car)<br>1982 Federal regulation<br>(CO, $NO_x$ is weber) g/mile | 0.35<br>(0.41) | 3.46<br>(7.0) | 0.65<br>(2.0) | |
| | VW Golf (California fleet car)<br>1981-82 California regulation g/mile | 0.27<br>(0.41) | 2.48<br>(7.0) | 0.57<br>(0.70*,0.40) | |
| ECE | Benz 280 SE<br>ECE 04 regulation g/test | 5.3<br>-- | 47.0<br>(84) | 5.5<br>-- | 10.8<br>(23.5) |
| | VW Golf (cab specification)<br>ECE 03 regulation g/test | 3.3<br>(6.5) | 33.4<br>(76) | 2.5<br>(8.5) | 5.8<br>-- |
| Japan 10 modes | Nissan Centraturbo<br>1978 regulation g/km | 0.02<br>(0.25) | 0.04<br>(2.1) | 0.21<br>(0.25) | |

* is optional

Table 2 gives the characteristics of the exhaust gas of the methanol engines. Figures in parentheses indicate the regulation limit for present gasoline vehicles. Values of CO and combustibles in the table satisfy the specification value for the gasoline car. However, $NO_x$ satisfies the optional specification value. In comparison with exhaust specifications of the basic gasoline car, $NO_x$ is reduced. However, combustibles and CO increase or decrease as the case may be.

(2) Neat Application Method (Reformation Method)--Concepts to reform methanol into CO and $H_2$ and expand the dilution limit by mixing the reformed gas into suction gas to reduce $NO_x$ and to improve fuel consumption ratio have been studied for some time. Reaction for the reform of methanol is an endothermic chemical reaction. Exhaust gas energy can be recovered by the exhaust heat exchanger. Assuming that all the methanol fed to the reformer is reformed, the calorific value of the methanol will be improved by 20 percent. To make this practical development of a car mount type exhaust heat reformer is mandatory, and improvement of heat exchanger performance is required. For this reason only a few examples of development as a vehicle system are available in spite of the basic research being implemented.

SERI (Solar Energy Research Institute) has developed a methanol reformed gas engine in cooperation with JPL (Jet Propulsion Laboratory).

Figure 3 shows the outline of the engine. Methanol is fed into the evaporator where heat from the engine coolant is transferred to methanol to transform it into methanol gas, which is introduced into the reformer after being superheated by exhaust gas through the heat exchanger. The gas, after being reformed into CO and $H_2$, will be cooled by the heat exchanger with engine cooling water and then introduced into the suction tube. Unconverted methanol and moisture will be recovered by a condensate trap.

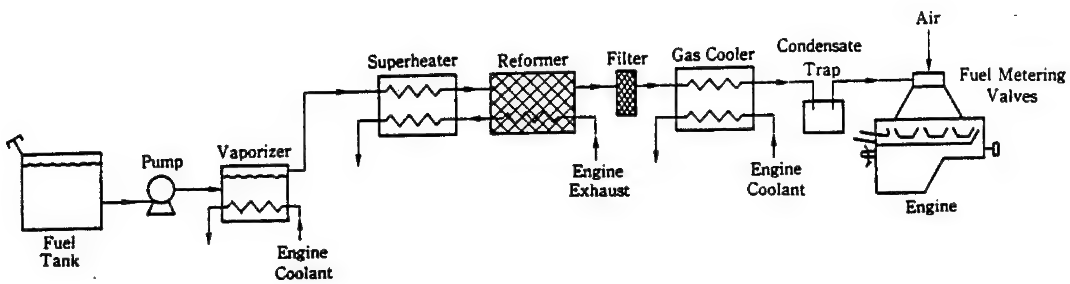



Figure 3. Methanol Reformed Gas Engine System

The combustible range of $H_2$ included in the reformed gas is wide, and dilute gas combustion is possible. However, abnormal combustion such as backfire is apt to occur under full load operation. Therefore, a dual carburetor system which controls equivalent ratio to constant by a gas throttling valve under very low load and controls fuel-feeding quantity in accordance with the load under higher load range, was manufactured on a trial basis. The result of a steady running test and FTP mode test performed by a vehicle mounted with trial-manufactured equipment indicated improvement of fuel consumption in comparison with gasoline. Improvement of fuel consumption under steady running (65 km/h) was 48 percent, and the value under HWFET mode operation was 31 percent.

VW has developed an engine system to heat the reactor by methanol burner applying partial oxidation reaction to improve low temperature starting of the methanol reformation gas engine. Figure 4 is a schematic drawing of the methanol reformed gas engine in which dotted lines indicate the fuel system during starting, and solid lines indicate the fuel system after the warming-up operation. At low temperature, methanol is burned by a methanol burner prior to starting the engine and is introduced into the reactor. The reactor is heated by the combustion gas, and the methanol is dissolved into CO and $H_2$ and is fed into the engine through a suction tube. After warming-up, the methanol will be fed into an exhaust gas heat exchanger and the evaporated methanol gas is introduced into the reactor. When the heat necessary for reformation becomes insufficient during the operation, the reactor will be fed with air to expedite partial oxidation reaction.

A four-cylinder engine of 1.6 liter displacement with a compression ratio of 12.6 was used for the test. The engine is fed only with reformed gas during

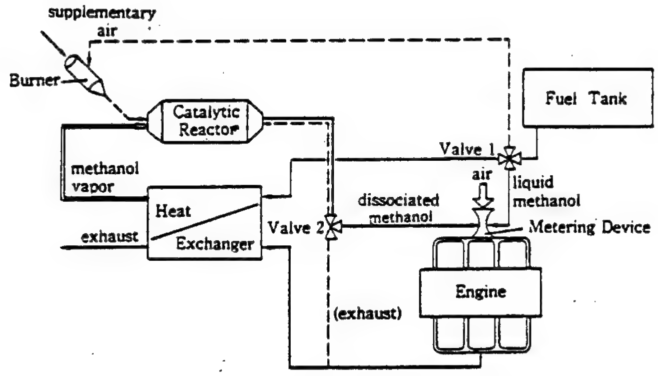



Figure 4. Partially Reformed Methanol Gas Engine

idling and low-speed operation, and liquid methanol was used during full load operation.

As a result of the independent test of the engine, 20 to 30 percent improvement of fuel consumption was obtained in comparison with gasoline, and 5 to 10 percent in comparison with liquid methanol. Moreover, $NO_x$ was reduced substantially because of dilute combustion, misfire did not occur at dilute mixture because of hydrogen containing fuel, and exhaust of combustible elements was reduced in comparison with liquid methanol.

JARI developed a prototype methanol reformed gas engine which can start at -15°C, and satisfies present gasoline engine exhaust gas regulations. The engine was modified from a commercial four-cylinder, 1.8 liter engine with a compression ratio of 8.8. A shell and tube type exhaust gas heating reformer was used. A methanol engine becomes difficult to start at ambient temperature of 10°C or below. Therefore, a cold state starter, which introduces a mixture of methanol and air into a layer of catalyzer and uses an electric heater for promoting reaction was developed. Figure 5 shows the structure of the cold state starter. The exothermic and endothermic energy of the reaction that occurred here are balanced. Therefore, reaction will be continued without the electric heater after it is started. Therefore, the capacity of the automobile battery will be sufficient for practical use.

Fuel consumption and exhaust gas characteristics under 10-mode running operation was calculated from the data of the steady state operation of an independent engine, and the results indicate about a 20-percent reduction of energy consumption in comparison with gasoline, and about 8 percent in comparison with liquid methanol. This engine is presently mounted on a vehicle and work is being performed for improvement of the control system to improve transient operation performance.

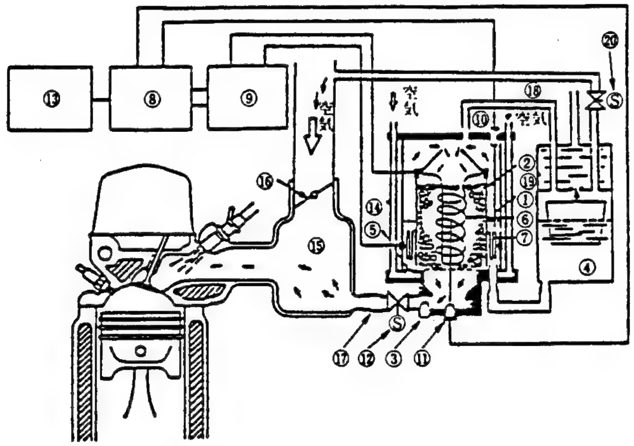


Figure 5. Constitution of Cold State Starter

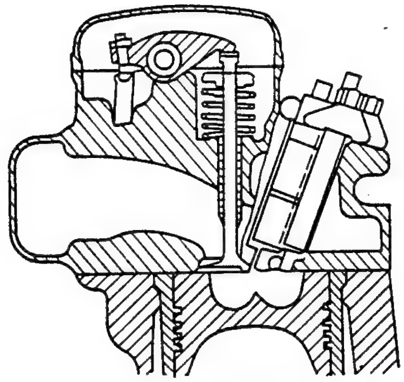
Key:
1. Bubbling tank
2. Catalyzer bed
3. Metering jet
4. Float chamber
5. Pore
6. Catalyzer heater
7. Alcohol heater
8. Temperature controller
9. Power unit
10. Thermocouple
11. Thermocouple
12. Stop valve
13. Control unit
14. Air introducing pipe
15. Common chamber
16. Throttle valve
17. Connecting tube
18. Air bleeding tube
19. Condenser
20. Stop valve
21. Air

2.2. Diesel Oil Substituting Technology

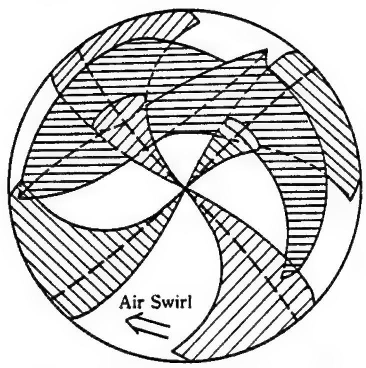
(1) Near-Neat Application System (Dual Fuel Injection System)

The dual fuel injection system can operate in a wide range from gas oil only to a 90-percent or more substitution of gas oil with alcohol, and is superior in starting and ignition stability characteristics compared with the neat application system. Therefore, it is specialized as the technology which can cope quickly with urgent requirements, and is one of the techniques which can be applied on the base of the conventional diesel engine in a relatively short period.

Volvo developed a dual fuel injection engine based on a 6-cylinder, 10-liter direct injection diesel engine with a compression ratio of 15. Figure 6 shows a sectional view of the combustion chamber and dispersion model of the mixture. Trucks and buses equipped with this engine are under fleet test in Sweden. A bus which has been running for 2 years in Stockholm indicated a 75-percent average gas oil substitution ratio. Characteristics of exhaust gas are given in Table 3, which indicates that $NO_x$ is reduced to half; however, CO increased to three times. Therefore, the oxidizing catalyzer was applied to result in a significant reduction of CO and combustible elements.



The cylinder head with two injectors




The fuel jets in the combustion chamber

Figure 6. Volvo Dual Fuel Injection System Engine

Table 3. Exhaust Gas of Methanol Diesel Engine (13-modes of the United States)

| Item | HC (g/hph) | CO (g/hph) | $NO_x$ (g/hph) | $NO_x$ + HC (g/hph) | Note |
|---|---|---|---|---|---|
| Volvo | 1.07 | 7.02 | 3.87 | 4.94 | Dual fuel injection system |
| | 0.12 | 0.61 | 4.99 | 5.11 | Dual fuel injection system with catalyzer |
| | 0.77 | 2.34 | 8.74 | 9.51 | Base engine |
| JARI | 0.25 | 4.02 | 3.14 | 3.39 | Dual fuel injection system |
| | 0.65 | 1.82 | 4.94 | 5.59 | Base engine |
| MAN | 0.30 | 0.70 | 4.10 | 4.40 | Spark ignition system |
| Komatsu, Ltd. | 0.20 | 0.13 | 3.80 | 4.00 | Spark ignition system |
| | 1.20 | 3.30 | 6.90 | 8.10 | Base engine |
| Benz | 0.39 | 5.36 | 3.90 | 4.29 | Methanol gas system |
| GM | 1.28 | 1.31 | 2.20 | 3.47 | Two-cycle auto-ignition system |
| Federal regulation | 0.50 | 15.50 | 9.00 | -- | |
| California regulation | 0.50 | 25.00 | -- | 4.50 | |

JARI has developed a prototype of dual fuel injection engine vehicle using a four-cylinder, 3.3-liter vortex chamber type diesel engine as the base, and is performing practical running tests. The section of the engine is indicated in Figure 7.

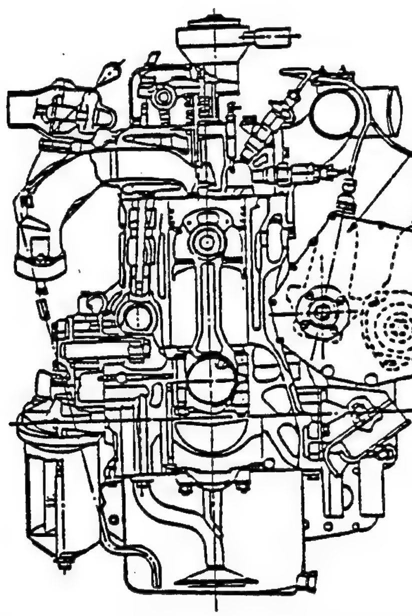


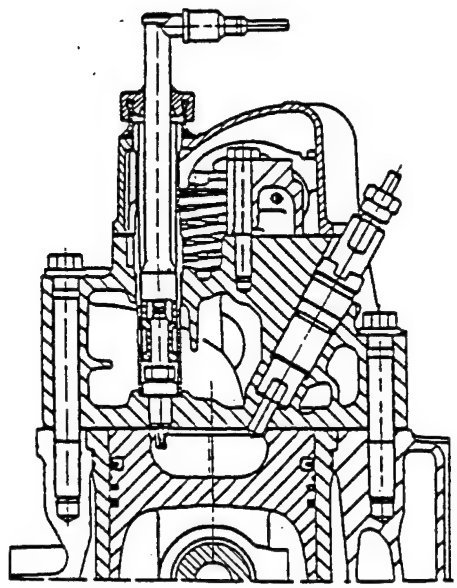

Figure 7. JARI Dual Fuel Injection System Engine

The rate of gas oil substitution of the prototype vehicle was about 75 volumetric percent when running in urban areas, about 85 volumetric percent when running at high speed and about 95 volumetric percent when running at constant speed. Actual running fuel consumption was the same as that of the base engine when running at high speed, but was worse at a maximum of 10 percent when running at low speed. Characteristics of exhaust gas are shown in Table 3. $NO_x$ and combustible elements were reduced and CO was increased. However, specifications were satisfied without using exhaust gas processing equipment. Test results of D6 mode were CO 472 ppm, HC 44 ppm, and $NO_x$ 207 ppm.

The prototype vehicle has been under general endurance testing since fiscal 1983, and no special problem has been experienced as of this time. However, a trace of seizure was observed on the plunger of the injection pump (type A of Bosch) from the independent test result of the fuel injection system, indicating large problems are yet to be solved.

(2) Neat Application System (Forced Ignition System)

Neat application system is the latest technology and there are many points yet to be clarified. However, its completion is expected from the point of 100-percent gas oil substitution.



M.A.N. D 2566 FMUH engine (development status 01/1984)

Figure 8. MAN Spark-Assisted Diesel Engine

MAN developed a methanol engine based on six-cylinder, 11.4-liter FM engine with a compression ratio of 8. Figure 8 indicates the sectional view of the engine combustion chamber, which is specialized by using a single injection hole nozzle. Injected fuel spreads along the combustion chamber wall and is ignited by a spark plug.

The fuel consumption rate is almost equal to that of the base engine, and was 210 g/kw·h (154 g/HP·h). Exhaust gas characteristics are indicated in Table 3, showing low CO and combustible elements because of using the oxidation catalyzer.

There are many problems yet to be solved, in relation to the durability of engine components. The spark plug was modified to make the projected electrode length shorter, and further a three-pole-type platinum tip electrode was adopted. However, the life is only about 20,000 km. Moreover, the delivery valve was improved to avoid cavitation of the methanol, but components subjected to high stress such as the nozzle, may require a change of design and/or materials.

The development vehicles are undergoing fleet testing in Europe and the United States, and the vehicles in the United States are participating in the Alcohol Fuel Transportation Demonstration Project of the CEC and perform commercial operation with methanol the bus of GM/DAA.

Komatsu, Ltd., has developed a prototype of a spark-assisted engine system using a direct injection six-cylinder, 6.5 liter with a compression ratio of

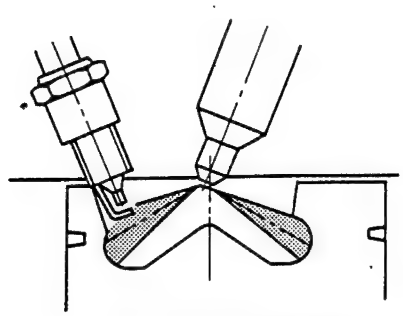



Figure 9. Spark-Assisted Engine of Komatsu, Ltd.

17.5 as the base. Configuration of the combustion chamber is shown in Figure 9. Ignition equipment of the CDI multispark system was adopted, and platinum was used on the electrode tip to avoid melting loss. The injection pump was changed from A type to P type, and a forced lubrication system was applied to prevent squeezing of the plunger barrel.

This engine is mounted on a 4-ton truck, and is presently continuing fleet testing. Fuel consumption under rated point is almost the same as that of the base engine. Exhaust gas characteristics are indicated in Table 3 showing low CO and combustible elements because an oxidation catalyzer is used. $NO_x$ is reduced to half in comparison to the base engine. Test results of D6 mode test were CO 80 ppm, HC 220 ppm, and $NO_x$ 330 ppm.

Paying attention to the low boiling point and great heat of vaporization of the methanol, Benz devised a new concept related to the methanol gas engine. The idea is to eliminate the necessity of vaporization heat being required when methanol is directly injected into the cylinder by gasifying the methanol with engine cooling water to reduce the compression work load, and also to improve thermal efficiency by recovering cooling loss energy.

Figure 10 indicates the sectional view of the combustion chamber. The base engine is a direct injection six-cylinder, 11.4-liter diesel engine with the compression ratio reduced to between 11.5 and 12.5. When starting at low temperature, the evaporator is heated and the exhaust gas heat exchanger is used in parallel after warming up.

The combustion pattern of the developed engine is similar to the gasoline engine. However, the engine can be operated without throttling under the mean effective pressure of 5 bar or higher, and attain a minimum fuel consumption rate of 208 g/kw·h (153 g/PS·h). Exhaust gas characteristics are indicated in Table 3, which shows that low CO and combustible elements were simultaneously reduced using a catalyzer.

Buses equipped with a methanol gas engine are continuously under fleet testing in West Germany, New Zealand, and other places.

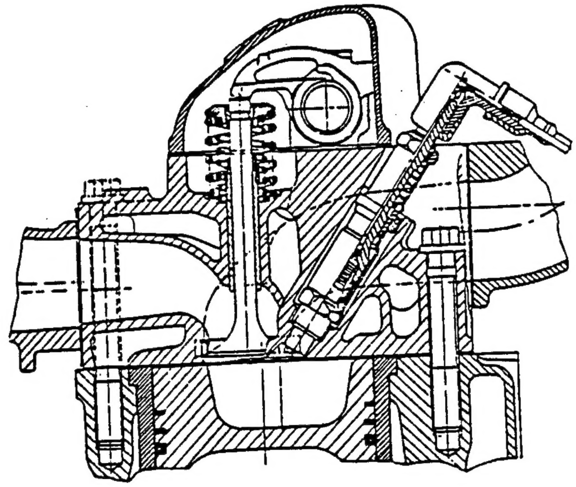
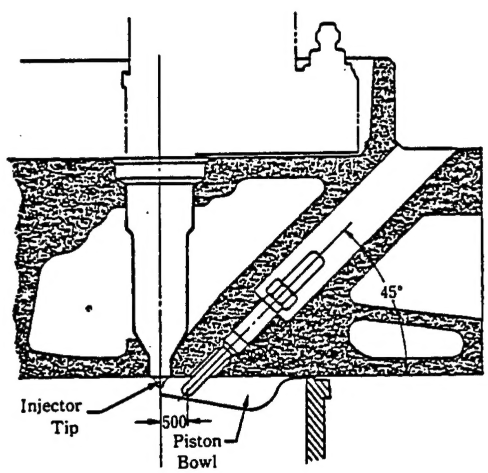


Figure 10. Alcohol Gas Engine of Benz

GM/DDA made possible auto-ignition of methanol in a two-cycle, six-cylinder, V-configuration engine with a compression ratio of 19 by adjusting the scavenging efficiency/quantity of residual gas. This is a specific feature of the two-cycle engine, and it is considered that active elements included in the residual gas are responsible for the auto-ignition. Under conditions of poor auto-ignition performance, such as during engine starting, low load operation, etc., electric current is run through a glow plug and the engine is ignited by force. Moreover, the fuel injection system, scavenging air quantity, etc., are electronically controlled for optimum operation conditions.




Cross-Section of Multicylin Head Showing Cast Boss

Figure 11. Auto-Ignition Engine of GM

Figure 11 shows a sectional view of the combustion chamber. The glow plug was applied as a forced ignition system. However, a spark plug was also tried at the early stage of development. It was found that ignition stability was not satisfactory with the spark plug, but steady ignition performance can be obtained by using a glow plug keeping the surface temperature to 1,625°F (885°C) or higher.

Table 3 indicates the characteristics of exhaust gas, showing that combustible elements are highest within the engine systems. Nonuse of a catalyzer is considered to be responsible. On the other hand $NO_x$ is lowest, showing specific features of the two-cycle engine.

The developed engine is mounted on a coach bus, and presently fleet testing is being performed in accordance with the CEC program in San Francisco.

## 3. Future of Alcohol Engine

### 3.1. Gasoline Substitution Application Technology

It is believed that no significant problem will arise in relation to the exhaust gas regulation in spite of the reduction of $NO_x$, and some increase of CO and combustibles. However, little data are available in relation to aldehydes, combustible alcohol, nitrite, etc., and this will be a big task, including the technology of the measurement method. Especially aldehydes are thought to be easily purified by catalyzer, but their concentration in exhaust is thought to increase greatly during cold starting and misfire by engine problem. For those points concerned, the development of an oxidation catalyzer for aldehydes, and improvements of technology for engine exhaust gas countermeasure are considered necessary.

In relation to the combustion specification, West Germany is improving starting capability by mixing isopentane to methanol. The mixing ratio of isopentane is 8.5 percent during the winter and 5.5 percent during the summer. In the United States, 15-percent gasoline is mixed in methanol for improving the startability and visibility at firing. In Japan, combustion specifications are yet to be determined, and their early establishment is desired.

In relation to the durability and reliability of the engine, highly durable and reliable gasoline engines are being developed based on extensive data. However, few data are available for the alcohol engine. For introducing the alcohol engine, it will be necessary to accumulate data related to durability and reliability during the lead time. Especially data for lubrication, wear, etc., are not sufficient, and development of special oil for alcohol will be a major future theme for research.

When considering the future of the alcohol engine as a substitute for the gasoline engine from these results, the purpose of introducing the alcohol engine is not only countermeasures for exhaust gas, but will be the security of obtaining a fuel supply. Therefore, the time for the introduction of the alcohol engine will be affected by the condition of the oil supply. As technology applying to engines, the turbocharger system is a promising homogeneous

method, and further study is desired for the reformed gas system, to make good use of the specific features of methanol.

3.2. Diesel Oil Substitution Application Technology

In relation to exhaust gas, alcohol has the specific features of low $NO_x$ and very low grain material, making possible smoke-free operation in comparison with the diesel engine. Exhaust characteristics of combustibles and CO are different in terms of application technology, but the quantity can be reduced easily by use of a catalyzer. However, the status of combustible alcohol, aldehydes, nitrite, etc., is similar to the case of gasoline substitution application technology.

As for durability and reliability of the engine, the solution of problems related to the fuel injection system, especially improvements in the injection pump plunger and injection nozzle, will be necessary. Further, improvement of durability of the spark plug is an important task. For large trucks, durability is one of the major tasks because of their long running distances and high engine load factor. Among the concepts presently being proposed, only the Benz gas engine and its methanol premixing gas oil ignition system does not require an injection pump. However, many problems remain to be solved.

From these results, diesel oil substituting application technology is attracting attention not only in terms of security, but also as an engine system for low pollution. The status is the same in the United States. Reduction of $NO_x$ and grain materials is an urgent problem in Japan, and introduction of an alcohol freight vehicle is desired. However, durability and reliability will not be guaranteed until practical measures for improvement of the injection nozzle and spark plug are available. Moreover, test vehicles are not enough, and many points, including inconsistency of quality when manufactured in bulk, have not been cleared up yet. It is expected that an appropriate appraisal will be made, by establishing fuel specifications to meet with Japan's actual circumstances, development of application technology, accumulation of data for durability and reliability by fleet testing, etc.

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